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# Holocene climatic fluctuation and lithic technological change in northeastern Hokkaido (Japan)

Kazuki Morisaki [a,*], Dai Kunikita [b], Hiroyuki Sato [b]

[a] Agency for Cultural Affairs, Government of Japan, 3-2-2, Kasumigaseki, Chiyoda-ku, 100-8959 Tokyo, Japan
[b] University of Tokyo, 7-3-1, Hongo, Bunkyo-ku, 113-0033 Tokyo, Japan

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ABSTRACT

In Japan, a body of archaeological assemblages with radiocarbon dates has been providing better understanding of relationship between lithic technology, pottery culture, settlement system, social change, and environment. This paper presented newly conducted radiocarbon dating on charred residue on potteries from Initial Jomon sites in northeastern Hokkaido. This work evidenced current pottery typological chronology and allows us to confirm diachronic lithic technological change associated with these potteries. Regarding the lithic technology, it became clear that lithic technological change into sophisticated blade technology suddenly occurred around 8400 cal BP, then lasted for very short time period until 8000 cal BP in northeastern Hokkaido, and that there was a clear technological gap between this sophisticated blade technology and the previous or subsequent simple flake technology. Since lithic raw material procurement strategy changed during this period, it is supposed that settlement system and foraging strategy might also be reorganized.

According to the correspondence between duration of the sophisticated blade technology and global climatic fluctuation, it is likely that 8.2 ka climatic event (maximum duration is roughly 8300–8050 cal BP) was responsible for this sudden change of blade technology. At present, regional environmental change driven by this global climatic fluctuation is not evidenced yet, but there is enough possibility that sudden appearance of sophisticated blade technology might have been caused not only by simple population dynamics or diffusion, but by rapid change in environmental condition.



## 1. Introduction

Recent progress of radiocarbon dating technology and increasing knowledge of palaeo-environment has been improving our understanding of human ecosystem (Butzer, 1982). Also in Japan, a body of archaeological assemblages with radiocarbon dates has been providing better understanding of relationship between lithic technology, pottery culture, settlement system, social change, and environment.

The final objective of our research project is also to approach, as much as possible, history of past human ecosystem from Palaeolithic to Neolithic Japanese Islands and Russian Far East. Since middle 2000s, we have accumulated radiocarbon dating on charred remain on potteries from early Neolithic sites in north Japan and Russian Far East, and continued technological analysis of lithic assemblages associating those potteries, aiming at elucidation of basic human-environment relationship.

As a preparatory step for this research, this paper shows the correlation between lithic technological changes with paleo-environmental change in Initial Jomon, early Neolithic, (11,000–7000 cal BP) of northernmost Japan (Hokkaido) on the basis of radiocarbon chronology.

Since Initial Jomon period, it is now well known that hunter-gatherers in Hokkaido started to live in pit-dwellings, utilized potteries, wooden tools, and flake lithic tools for hunting, fishing, and gathering lifeway (e.g. Okamura 1997; Nomura and Udagawa, 2001; Yamahara 2008; Tominaga 2008). However, the other assemblages, which are characterized not by flake technology and tools but by sophisticated blade technology, are also known during this period in northeastern Hokkaido. Although the existence of these assemblages was explained mainly by population migration or cultural diffusion from northern regions of Asian mainland, recent study implies it was somehow caused by climate change (Yamahara 2008).

To better understand this problem, this paper aims at clarifying the duration of each pottery type and blade industry by radiocarbon dating,

* Corresponding author at: 3-2-2, Kasumigaseki, Chiyoda-ku, 100-8959 Tokyo, Japan.
*E-mail addresses:* morisaki@bunka.go.jp (K. Morisaki), dkunikita@yahoo.co.jp (D. Kunikita), hsato@l.u-tokyo.ac.jp (H. Sato).

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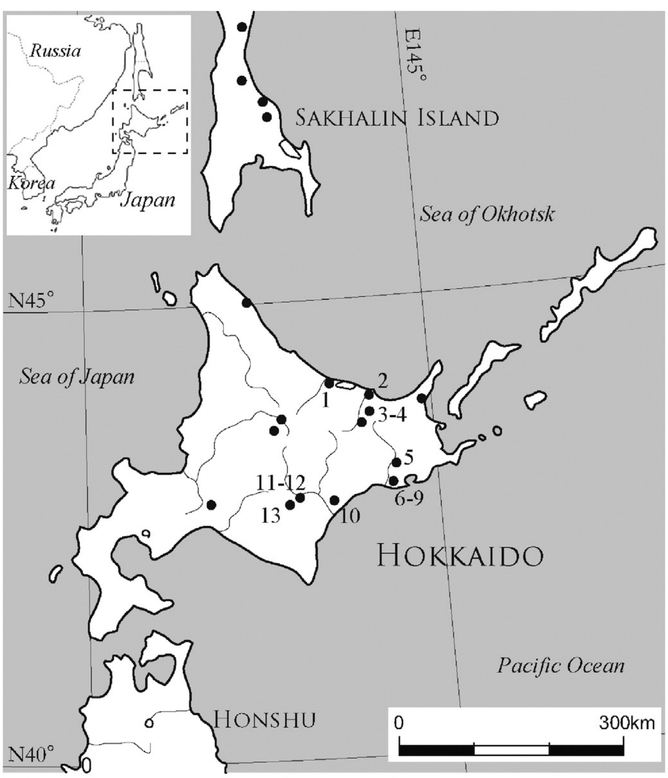
and correlates them with the Holocene climatic fluctuation. This will show if there is relationship between lithic technology and environmental change, and the reason for the existence of sophisticated blade technology.

## 2. Material and methods

### 2.1. Pottery typology and radiocarbon dating

Materials were obtained from Initial Jomon sites in northeastern Hokkaido, which were securely excavated and have clear provenience data of artifacts including lithic tools and potteries. In particular, potteries must have charred residue on the surface for radiocarbon dating. Finally, a total of 13 sites, which are all representative in the region, were picked out according to above conditions.

The analyzed sites are located in the eastern area of Hokkaido, Japan (Fig. 1). The northeastern Hokkaido is located at the north edge of Japanese Islands, facing the Sea of Okhotsk and the Pacific Ocean. The area along the Pacific Ocean is Tokachi and Kushiro region and those along the Sea of Okhotsk is Okhotsk region. The former includes 9 sites (Tokachi District: Yachiyo A (Obihiro City Board of Education, 1990), Taisho 3, 7 (Obihiro City Board of Education, 2006), Kyoei B (Urahoro Town Board of Education, 1976), Kushiro District: Sakuragaoka 2 (Kushiro Kokogaku Kenkyukai 1987, 1988), Zaimokutyo 5 (Kushiro Kokogaku Kenkyukai 1990), Higashikushiro I (Sawa et al. 1971a, 1971b), II (Iwasaki et al. 1980), Futatsuyama 1 (Toyohara 2000a, 2000b)), the latter includes 4 sites (Abashiri District: Tokoro shell mound (University of Tokyo, Faculty of Letters, 1963), Memanbetsutoyosato (Memanbetsu Town Board of Education, 1992), Chuo A (Yonemura 1997), Monbetsu District: Yubetsuichikawa I (Yubetsu-Ichikawa research team, 2015)). Yachiyo A, Taisho 3, 7, Futatsuyama 1, Memanbetsutoyosato, Chuo A sites are respectively located in the inland area of Hokkaido.




1. Yubetsu-Ichikawa
2. Tokoro Shell Mound
3. Memanbetsu-toyosato
4. Chuo A
5. Futatsuyama 1
6. Higashikushiro I
7. Higashikushiro II
8. Sakuragaoka 2
9. Zaimokucho 5
10. Kyoei B
11. Taisho 3
12. Taisho 7
13. Yachiyo A

**Fig. 1.** Distribution of sites mentioned in this paper.

Potteries from these sites can be classified into 10 pottery types (and groups) by current Jomon pottery typology (e.g. Sawa 1968; Sato 1980; Nishi 1997; Kitazawa 2008; Goto and Yamahara 2008). Past thorough typological studies has sorted these types as follows from oldest to newest during Initial Jomon period; Tenneru and Akatsuki type (early Initial Jomon), Numajiri type, Higashikushiro I type > Memanbetsu type, Tokoro 14 type, Urahoro type, Yubetsuichikawa I group, and Taisho IV group (early half of late Initial Jomon) > Higashikushiro II type, Higashikushiro III type (late half of late Initial Jomon). Yubetsuichikawa I group (Investigation team of the Yubetsu-Ichikawa site 2015) is quite similar to Tokoro 14 type and Urahoro type, and could be rearranged into these types. Taisho IV group, likewise, includes Memanbetsu type and Urahoro type potteries. Though this typological difficulty should be cleared in the future, this paper considers these two group as a sort of variant of pottery types in early half of late Initial Jomon period.

Of these, radiocarbon dating analyses were conducted on 73 charred residues on pottery. Sample preparation for $^{14}$C dating was done according to Yoshida et al. (2004). The concentration of the alkali treatment for the charred remains on pottery was used of a level at which the test sample did not dissolve completely. The measurements were taken using the Micro Analysis Laboratory, Tandem accelerator (MALT) at the University of Tokyo. The C/N analysis of the carbon-nitrogen isotope ratio was conducted using an IsoPrimeEA Stable Isotope Ratio Mass Spectrometer (Micromass, UK) at the Laboratory for Radiocarbon Dating in the Department of Research, University Museum, The University of Tokyo and Stable Isotope Ratio Mass Spectrometer (Thermo Fisher Scientific, Flash EA1112) at the SI Science Co., Ltd.

### 2.2. Lithic technological analysis

Lithic assemblages which are evidently associated with the dated potteries were carefully selected for technological analysis. Finally, 15 assemblages of 13 sites were picked out for this analysis.

We discuss lithic technology that reflects human behavioral strategies, focusing on characteristics of lithic raw material which reflects procurement strategy, and on composition of stone hunting weapons, processing tools, stone net sinker (roughly flaked pebbles) and also on primary reduction as tool blank producing technology. Primary reduction and tool assemblage indicates basic behavioral strategy of humans, and net sinkers are a marker of highly sedentary lifeway. Consequently if humans are somehow influenced by climatic change, there would be change in lithic.

Two primary reductions are recognized; flake and blade. Particularly, as for blade technology, we analyzed it in more detail, focusing on profile of blade, platform type, bulb shape.

As for stone hunting weaponry, three major types of the time period of focus can be identified; chipped arrowheads on flake (Fah) or on Blade (Bah), and bifacial points.

## 3. Results

### 3.1. Radiocarbon dating

Table 1 and Fig. 2 present the $^{14}$C dates and carbon and nitrogen isotope ratios of the charred materials. We obtained dates from 8560-7040 BP for 13 sites. The Akatsuki and Tenneru type were dated to 8430-7920 BP, Numajiri type to 8560-7840 BP, Higashikushiro I type to 8410-8080

**Table 1**
$^{14}C$ ages and $\delta^{13}C$, $\delta^{15}N$, C/N values of charred remains on pottery.

| Culture, pottery type | Site | Sample nr | Sampling Position | $^{14}C$ age BP(1σ) | Lab nr | $\delta^{13}$CPDB (‰) | $\delta^{15}$NAIR (‰) | C/N ratio |
|---|---|---|---|---|---|---|---|---|
| Akatsuki/Tenneru | Yachiyo A | YachiyoA-P23 | Inner, Rim | 8430 ± 50 | MTC-16158 | −22.0 | 13.1 | 8.1 |
| | | YachiyoA-P21 | Inner, Rim | 8190 ± 50 | MTC-16156 | −24.1 | 10.9 | 8.2 |
| | | YachiyoA-P14 | Inner, Rim | 8160 ± 50 | MTC-16153 | −24.4 | 11.2 | 12.0 |
| | | YachiyoA-P22 | Inner, Rim | 8130 ± 50 | MTC-16157 | −25.2 | 7.1 | 10.4 |
| | | YachiyoA-P20 | Inner, Rim | 8000 ± 50 | MTC-16155 | −25.0 | 8.8 | 13.1 |
| | | YachiyoA-P19 | Inner, Rim | 7920 ± 50 | MTC-16154 | −24.3 | 9.0 | 11.5 |
| | Sakuragaoka 2 | 05SG-6 | Inner, Rim | 8270 ± 80 | TKa-13965 | −23.3 | – | 10.8 |
| | | 05SG-7 | Inner, Rim | 8070 ± 130 | TKa-13966 | −24.8 | – | 10.6 |
| Numajiri | Yachiyo A | YachiyoA-P17 | Inner | 8495 ± 45 | MTC-16855 | −21.4 | 13.3 | 10.9 |
| | | YachiyoA-P18 | Inner, Rim | 8270 ± 50 | MTC-16856 | −21.9 | 14.3 | 10.4 |
| | | YachiyoA-P16 | Inner, Rim | 8040 ± 50 | MTC-16854 | −22.4 | 14.1 | 10.2 |
| | Higashikushiro I | HKI-P21 | Inner, Rim | 8260 ± 60 | MTC-17519 | −22.1 | 13.4 | 12.7 |
| | Higashikushiro II | HKII-P9 | Inner, Body | 8560 ± 60 | MTC-17518 | −22.4 | 15.9 | 11.5 |
| | | HKII-P8u | Inner, Body | 8270 ± 60 | MTC-17516 | −21.9 | 15.0 | 11.5 |
| | | HKII-P8s | Outer, Rim | 8140 ± 70 | MTC-17517 | −23.2 | 14.6 | 17.4 |
| | | HKII-P7 | Inner, Rim | 8140 ± 70 | MTC-17515 | −22.1 | 14.9 | 10.9 |
| | | HKII-P6 | Outer, Rim-body | 8120 ± 60 | MTC-17514 | −23.9 | 13.3 | 17.8 |
| | Zaimokucho 5 | ZM5-P17 | Inner, Rim-body | 8550 ± 60 | MTC-17520 | −23.2 | 13.8 | 19.1 |
| | Chuo A | 05COA-40 | Inner, Rim | 8005 ± 35 | TKa-13933 | −23.6 | 12.7 | 14.8 |
| | | 05COA-39 | Inner, Rim | 7935 ± 45 | TKa-13932 | −23.6 | 12.1 | 10.0 |
| | | 05COA-36 | Inner, Rim | 7880 ± 40 | TKa-13930 | −24.4 | 9.8 | 14.9 |
| | | 05COA-38 | Inner, Rim | 7840 ± 50 | TKa-13931 | −23.9 | 13.5 | 13.6 |
| Higashikushiro I | Higashikushiro I | HKI-P12 | Inner, Rim | 8250 ± 60 | MTC-17523 | −21.5 | 14.8 | 9.7 |
| | | HKI-P13 | Inner, Rim | 8210 ± 60 | MTC-17524 | −20.4 | 14.1 | 8.7 |
| | | HKI-P10 | Inner, Body | 8130 ± 60 | MTC-17521 | −22.5 | 11.8 | 10.2 |
| | | HKI-P11 | Inner, Rim | 8080 ± 60 | MTC-17522 | −20.3 | 14.1 | 9.6 |
| Memanbetsu | Futatsuyama 1 | 05FY-9 | Inner, Rim | 7610 ± 50 | TKa-13935 | −23.0 | – | 9.5 |
| | Memanbetsu-toyosato | 05TS-35 | Inner, Body | 7970 ± 35 | TKa-13770 | −22.6 | 14.2 | 9.0 |
| | | 05TS-29 | Inner, Rim | 7930 ± 40 | TKa-13764 | −22.3 | 15.6 | 9.6 |
| | | 05TS-31 | Inner | 7775 ± 45 | TKa-13766 | −22.8 | 13.3 | 9.9 |
| | | 05TS-33 | Inner, Rim | 7695 ± 40 | TKa-13768 | −20.9 | 11.4 | 8.1 |
| | | 05TS-34 | Inner, Rim | 7680 ± 45 | TKa-13769 | −21.6 | 9.0 | 8.9 |
| | | 05TS-30 | Inner, Rim | 7665 ± 40 | TKa-13765 | −20.3 | 15.7 | 9.3 |
| | | 05TS-32 | Outer | 7645 ± 40 | TKa-13767 | −24.5 | – | 14.7 |
| Tokoro 14 | Tokoro shell mound | 05TR-26 | Inner, Rim | 7960 ± 50 | TKa-13908 | −22.3 | 10.8 | 11.0 |
| | | 05TR-21 | Inner, Rim | 7830 ± 40 | TKa-13903 | −23.2 | 13.0 | 10.1 |
| | | 05TR-25 | Inner, Body | 7780 ± 50 | TKa-13907 | −19.5 | 11.7 | 7.0 |
| | | 05TR-22 | Inner, Rim | 7525 ± 45 | TKa-13904 | −23.1 | 12.4 | 11.2 |
| | | 05TR-23 | Inner, Rim | 7505 ± 45 | TKa-13905 | −21.9 | 6.5 | 10.1 |
| | | 05TR-24 | Inner, Rim | 7495 ± 40 | TKa-13906 | −21.0 | 9.5 | 7.7 |
| Yubetsu-Ichikawa I | Yubetsu-Ichikawa | 13YBI-P28 | Outer, Bottom | 8000 ± 60 | MTC-17017 | −23.6 | 14.5 | 14.6 |
| | | 13YBI-P23 | Inner, Rim | 7945 ± 40 | MTC-17448 | −21.4 | 16.2 | 9.0 |
| | | 13YBI-P5 | Outer, Body | 7930 ± 60 | MTC-17273 | −25.4 | 5.6 | 103.9 |
| | | 13YBI-P1 | Inner, Rim | 7890 ± 50 | MTC-17175 | −22.7 | 16.5 | 9.8 |
| | | 13YBI-P34 | Lip | 7860 ± 50 | MTC-17016 | −22.2 | 14.9 | 11.2 |
| | | 13YBI-P9 | Inner, Rim | 7810 ± 40 | MTC-17447 | −23.1 | 11.7 | 14.4 |
| | | 13YBI-P10 | Inner, Rim | 7715 ± 40 | MTC-17449 | −23.2 | 14.0 | 11.9 |
| | | 13YBI-TP1 | Inner, Rim | 7690 ± 50 | MTC-17176 | −22.5 | 13.8 | 10.7 |
| | | 13YBI-13re | Inner, Rim | 7660 ± 40 | MTC-17433 | −22.7 | 13.9 | 9.8 |
| | | 13YBI-P14 | Inner, Rim | 7560 ± 60 | MTC-17275 | −24.0 | 9.1 | 11.6 |
| | | 13YBI-P33 | Inner, Body | 7490 ± 60 | MTC-17119 | −27.0 | 2.3 | 19.1 |
| Taisho IV | Taisho 3 | Taisho3-P11 | Inner, Rim | 7880 ± 45 | MTC-16850 | −22.4 | 15.1 | 8.8 |
| | | Taisho3-P9 | Inner | 7730 ± 50 | MTC-16848 | −22.8 | 13.0 | 10.1 |
| | Taisho 7 | Taisho7-P10 | Inner, Rim | 7900 ± 50 | MTC-16849 | −22.8 | 13.7 | 12.4 |
| | | Taisho7-P12 | Inner, Rim | 7740 ± 50 | MTC-16851 | −22.0 | 13.3 | 9.4 |
| | | Taisho7-P7 | Inner | 7685 ± 45 | MTC-16846 | −23.3 | 13.9 | 12.4 |
| | | Taisho7-P8 | Inner | 7590 ± 50 | MTC-16847 | −22.4 | 13.0 | 9.0 |
| Urahoro | Kyoei B | KyoeiB-P7 | Inner, Rim | 7855 ± 45 | MTC-16863 | −20.3 | 14.3 | 9.7 |
| | | KyoeiB-P8 | Inner, Rim | 7695 ± 45 | MTC-16864 | −23.0 | 12.9 | 11.1 |
| | | KyoeiB-P6 | Inner, Rim | 7630 ± 50 | MTC-16862 | −21.6 | 14.1 | 9.3 |
| | Higashikushiro II | 05HKII-5 | Inner, Bottom | 7460 ± 100 | TKa-13964 | −23.9 | 11.6 | 10.5 |
| | | 05HKII-4 | Inner, Rim | 7440 ± 70 | TKa-13963 | −23.1 | 16.9 | 9.0 |
| | | 05HKII-1 | Outer, Rim | 7430 ± 90 | TKa-13960 | −24.1 | – | 14.9 |
| Higashikushiro II | Higashikushiro I | HKI-P20 | Outer, Body | 7430 ± 60 | MTC-17526 | −23.6 | 10.9 | 33.3 |
| | Sakuragaoka 2 | SG2-P5 | Inner, Body | 7630 ± 60 | MTC-17527 | −22.2 | 14.2 | 12.8 |
| | | SG2-P22 | Inner, Rim | 7590 ± 60 | MTC-17528 | −22.6 | 13.8 | 10.5 |
| | Yubetsu-Ichikawa | 13YBI-P8 | Inner, Body | 7450 ± 60 | MTC-17274 | −24.1 | 12.2 | 12.6 |
| Higashikushiro III | Higashikushiro I | HKI-P19 | Inner, Body | 7400 ± 60 | MTC-17529 | −20.7 | 15.6 | 8.0 |
| | Sakuragaoka 2 | SG2-P18 | Inner, Rim | 7460 ± 60 | MTC-17530 | −23.3 | 13.4 | 18.1 |
| | Yubetsu-Ichikawa | YBI-2 | Inner | 7345 ± 45 | MTC-16884 | −22.2 | 15.1 | 10.1 |
| | | YBI-1 | Inner, Rim | 7160 ± 45 | MTC-16883 | −23.5 | 13.5 | 12.4 |
| | | YBI-4 | Inner | 7160 ± 45 | MTC-16886 | −24.3 | 11.3 | 10.8 |
| | | YBI-7re | Inner | 7040 ± 50 | MTC-17163 | −23.5 | 13.2 | 12.9 |

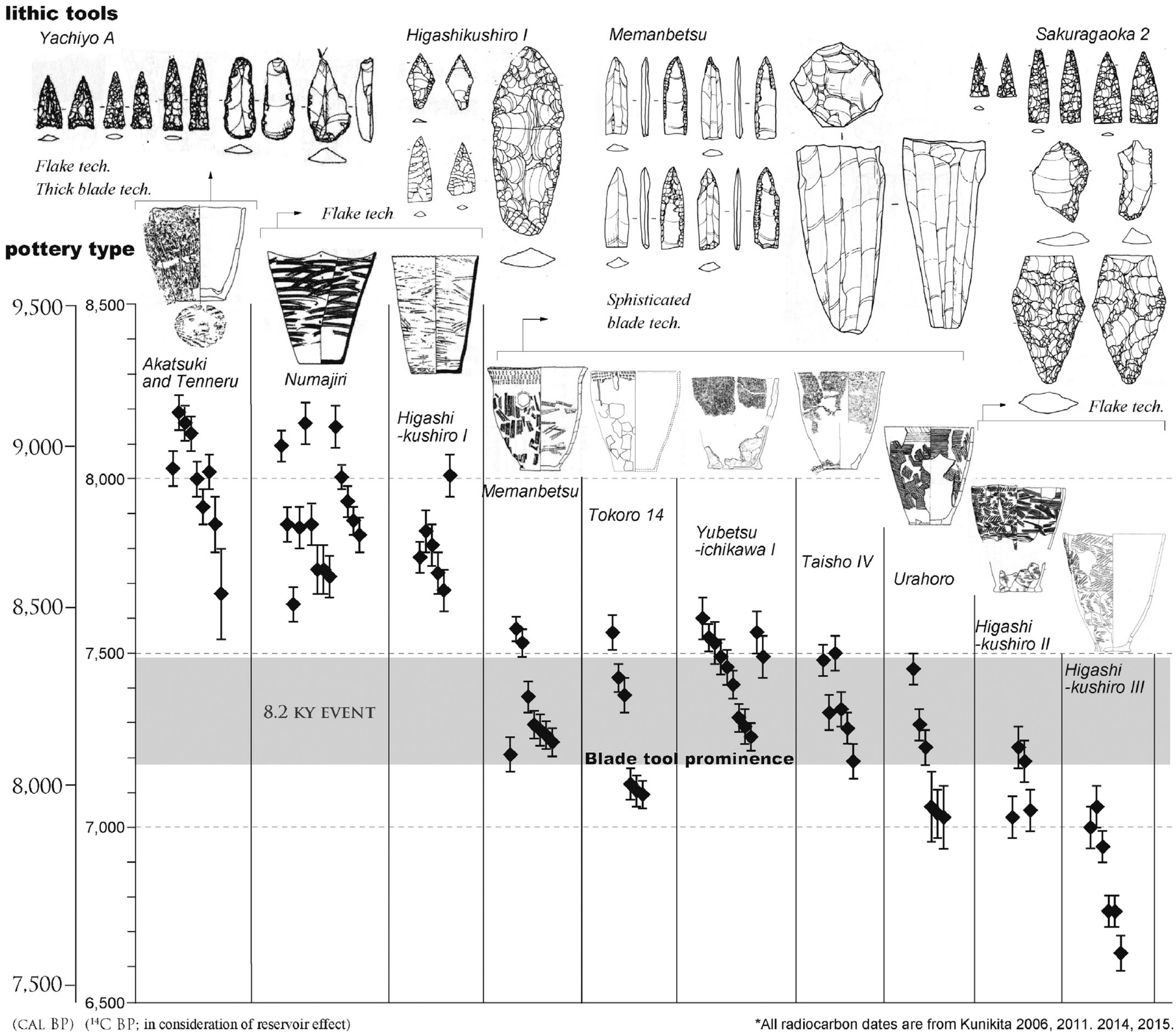



**Fig. 2.** Lithic technological change and pottery types with numerical ages at 1σ. All are cal. yr B.P.

BP, Memanbetsu type to 7970-7610 BP, Tokoro 14 type to 7960-7495 BP, Yubetsuichikawa I group to 8000-7490 BP, Taisho IV group to 7900-7590 BP, Urahoro type to 7855-7430 BP, Higashikushiro II type to 7630-7430 BP, Higashikushiro III type to 7460-7040 BP. Our radiocarbon dating well matched with the past chronology by typological studies, and confirmed it.

There are several problems with conducting research related to dating of charred residues on pottery in Northeast Asia. This problem is that charred residues found on pottery within a clear context tend to be older than the true ages, due to marine and freshwater reservoir effects. The age gap between charred remains on pottery and wood charcoal was estimated as approximately 400 BP on the average and maximum 800 BP (Kunikita et al. 2013). The reporting of reservoir age, which reflects the past intensity of upwelling in these areas, has been substantially constant in the eastern area of Hokkaido. The mean ΔR values as regional reservoir correction were estimated for the water belonging to the western part of the subarctic gyre as 393 ± 32 $^{14}C$ years (Kuzmin et al. 2001; Yoneda et al. 2007). The carbon and nitrogen isotope ratios of the charred residues found on pottery can be used to refine the archaeological chronology. In particular, charred residues on pottery of high values of both $\delta^{13}C$ and $\delta^{15}N$ and low C/N ratio could show older dates (Kunikita et al. 2007, 2013). In this paper, we assume that the marine reservoir effect as seen on charred remains on pottery are 400 BP, dates from which reservoir age are subtracted. However, samples from the Yachiyo A site (except MTC-16158), the Chuo A site and part of the Yubetsuichikawa site, which had a low distribution of both $\delta^{13}C$ and $\delta^{15}N$, could be several hundred years younger than the other ages. Since the Yachiyo A and the Chuo A site were respectively located in the inland, food habits of these sites were assumed to have had a lower dependency on marine resources and anadromous fish such as salmonids, and the marine reservoir ages as 400 BP were not assumed. However, the relationships between $\delta^{13}C$, $\delta^{15}N$, and $^{14}C$ dates of charred residues in these areas vary widely (<800 BP), so it is difficult to accurately recalibrate the $^{14}C$ dates using $\delta^{13}C$ and $\delta^{15}N$ values of charred residues. We assumed that the charred remains with high values of both $\delta^{13}C$ and $\delta^{15}N$ and a low C/N ratio (about $\delta^{13}C > -24‰$, $\delta^{15}N > 12‰$, C/N < 12) except the above samples are derived exclusively from marine resources, mostly salmon and trout moving upstream.

Taking this reservoir effect into account, calibrated ages of the dates above were estimated as follows: The Akatsuki and Tenneru type was

9200–8300 cal BP, Numajiri type was 9200–8300 cal BP, Higashikushiro I type was 9000–8400 BP, Memanbetsu type was 8400–7900 cal BP, Tokoro 14 type was 8400–7800 cal BP, Yubetsuichikawa I group was 8500–8000 cal BP, Taisho IV group was 8400–7900 cal BP, Urahoro type was 8400–7700 cal BP, Higashikushiro II type was 8200–7800 cal BP, Higashikushiro III type was 8000–7400 cal BP.

### 3.2. Lithic technological analysis

As for technological analysis (Table 2 and Fig. 2), lithic assemblages of 9000–8400 cal BP, which are associated with Akatsuki and Tenneru type, Numajiri type, and Higashikushiro I type potteries, are made up of flake tools including pentagonal, diamond-shaped and triangular arrowheads, bifaces, scrapers, burins, and drills in addition to pebble tools such as net sinkers. Ground axes are few but usually associated. Dominance of burins should be noted.

Tool blanks are elongated flakes or thick small blades, which are produced by flake or rough blade technology with direct percussion technique. For example, in Yachiyo A site, most lithic tools are made on small thick blades, which is different from lithic assemblage in Honshu. However, lithic assemblage from Chuo A site, a bit later than Yachiyo A site, is made up of completely flake tools, lacking blade tools like those in Yachiyo A site. Pentagonal and diamond-shaped arrowhead dominates in this site.

Lithic raw material for these tools is mostly small obsidian pebble (Obihiro City Board of Education, 2008), which could be collected easily and more widely than the debris which could be gain just around outcrops.

By contrast, those of 8400–8000 cal BP, which are associated with Memanbetsu type, Tokoro 14 type, Yubetsu-Ichikawa I group, and Taisho IV group potteries, are composed of a variety of blade tools including blade arrowheads, end scrapers, side scrapers, and burins. A number of net sinkers are still usually associated here. Ground axes are relatively few but usually found.

In this period, primary reduction suddenly changed. Unlike thick and small blades in the previous period, blades of this period are thin without twist, and have straight edge, small bulb and faceted small plat form. These characteristics imply application of indirect or pressure flaking technique in detaching blades. All tools are well elaborately retouched and standardized.

This blade technology is applied on large obsidian debris, which is not available in any place other than obsidian outcrops in mountainous area. It is thought that hunter-gatherers of this period in northeastern Hokkaido conducted direct procurement activity near obsidian sources, because there are only a few sites of this period near obsidian sources in central Hokkaido, they seem to have collected obsidians without occupation there (Takakura 1999: Yamada, 2011; Investigation team of the Yubetsu-Ichikawa site 2015: 54-55p.).

There are only a few sites after 8000 cal BP. Lithic assemblages from Sakuragaoka 2 site pit-dwelling 1, 8, 17, which accompany Higashikushiro II and III type potteries, consist of flake tools as triangular arrowheads, bifaces, side scrapers, and burins without blade tools. Blade tools are very few or usually lost after 8000 cal BP. Obsidian as lithic raw material is basically pebble, though debris is also known (Obihiro City Board of Education, 2008: 383p.). There is almost no evidence that blade technology was used after this stage.

## 4. Discussion

### 4.1. Summary of the result

Our analysis newly added 76 radiocarbon dates to the past chronological study, and confirmed and made it finer. Using these dates, we can evidence lithic technological change in more detail than ever.

According to the data of this paper's work, now it became clear that lithic technological change into sophisticated blade technology suddenly occurred around 8400 cal BP, then lasted for very short time period until around 8000 cal BP in northeastern Hokkaido, and that there was a clear technological gap between this sophisticated blade technology and the previous or subsequent technology. Since lithic raw material procurement strategy changed during this period, it is supposed that settlement system and foraging strategy were also reorganized.

Other than the materials used in this paper, Taisho 6 site (Obihiro City Board of Education, 2005) has the oldest phase of the Akatsuki and Tenneru type pottery which were dated as 9260 ± 40 (Beta-194635), 9550 ± 40 (Beta-194636) and predates Yachiyo A assemblage. Lithic assemblage of this site consists mainly of flake tools, including chipped arrowhead, bifaces, burins, scrapers, and drills. Tool blanks are elongated flakes or thick small blades which are produced by flake or rough blade technology with direct percussion technique. This assemblage is well consistent with those of other sites with the Akatsuki and Tenneru type pottery analyzed in this paper. Given these dates, calibrated ages of the Akatsuki and Tenneru type pottery wholly ranges from 10,500 to 8300 cal BP.

**Table 2**
List of lithic assemblages.

| Pottery type | Site/Arhcaeological feature | Primary reduction | Major hunting weapons | Processing tools | Net sinker | Reference |
|---|---|---|---|---|---|---|
| Akatsuki/Tenneru | Yachiyo A | Blade, Flake | Fah | Br, Sc, Ax | + | Obihiro City Board of Education (1990) |
| | Sakuragaoka 2/Pd-15 | Flake | Fah | Sc | + | Kushiro Kokogaku Kenkyukai (1987) |
| Numajiri | Zaimokucho 5 | Flake | n/a | n/a | + | Kushiro Kokogaku Kenkyukai (1990) |
| | Chuo A | Flake | Fah (pentagonal, diamond) | Sc, Dr, Ax | + | Yonemura (1997) |
| Higashikushiro I | Higashikushiro I | Flake | Fah (pentagonal, diamond), Biface | Sc | + | Sawa et al. (1971a, 1971b) |
| Memanbetsu | Futatsuyama loc.1 | *Blade* (Flake) | Bah, Biface | Sc, Ax | + | Toyohara (2000a, 2000b) |
| | Memanbetsu-toyosato | *Blade* (Flake) | Bah, Fah, Biface | Sc, Ax | + | Memanbetsu Town Board of Education (1992) |
| Tokoro 14 | Tokoro shell mound, loc.F | *Blade* (Flake) | Bah, (Fah) | Sc, Ax | + | University of Tokyo, Faculty of Letters (1963) |
| Urahoro | Kyoei B | *Blade* | Bah | Br, Dr, Sc, Ax | | Urahoro Town Board of Education (1976) |
| | Higashikushiro II | *Blade* | Bah | Sc, Br | + | Iwasaki et al. (1980) |
| Yubetsu-Ichikawa I group | Yubetsu-Ichikawa I | *Blade* | Bah (Fah) | Sc, Br, Dr, Ax | | Yubetsu-Ichikawa research team (2015) |
| Taisho IV group | Taisho 3 | *Blade* | Bah | Sc, Ax | + | Obihiro City Board of Education (2006) |
| | Taisho 7 | *Blade* | Bah, Biface, (Fah) | Sc, Br, Ax | | Obihiro City Board of Education (2006) |
| Higashikushiro II | Sakuragaoka 2/Pd-17 | Flake | Fah (pentagonal), Biface | Sc | | Kushiro Kokogaku Kenkyukai (1988) |
| Higashikushiro III | Sakuragaoka 2/Pd-1.8 | Flake | Fah (pentagonal), Biface | Sc | | Kushiro Kokogaku Kenkyukai (1987) |

Italicized 'Blade' indicates sophisticated blade technology.

Also regarding lithic technology after 8000 cal BP, lithic assemblage with Higashikushiro II/III type pottery from Taisho 8 site (Obihiro City Board of Education, 2008) shows clear resemblance with this paper's analysis on Sakuragaoka 2 site. This assemblage was dated from 7500 to 7000, which can be calibrated as 8000–7400 cal BP considering reservoir effect.

These radiocarbon data and lithic technological analysis completely support this paper's result.

### 4.2. Holocene climatic condition

Unlike climatic condition during Pleistocene, climatic stability has been recognized since the onset of Holocene, but several short spike of oxygen isotope ratio was also known. The most prominent Holocene climatic event in Greenland ice-core proxies, with approximately half the amplitude of the Younger Dryas, occurred around 8.2 kyr B.P. (Alley et al. 1997), and it affected regions well beyond the North Atlantic basin. “The spatial pattern of terrestrial and marine changes is similar to that of the Younger Dryas event, suggesting a role for North Atlantic thermohaline circulation” (Alley and Ágústsdóttir, 2005). Total duration is estimated to be roughly 150 years (Kobashi et al. 2007).

The degree of climatic influence of this event in East Asia is detailed by several data (Wang et al. 2005; Selvaraj et al., 2008; Cheng et al. 2009). Cheng et al. (2009) evidenced that $\delta^{18}$O records of stalagmite from Dongge Cave in China, Qunf Cave in Oman, and Padre Cave and Paixão Cave in Brazil shows that Asian Monsoon weakening and South American Summer Monsoon strengthening started in between 8.30 and 8.21 kry BP, the abrupt change occurred ca. 8.21 $\pm$ 0.02 kyr BP, and abrupt termination of the event occurred 8.08 $\pm$ 0.03 kyr BP.

According to their study, maximum duration of 8.2 ka event in East Asia is estimated to be roughly 8300–8050 cal BP.

### 4.3. Lithic technological change and climatic event

As well evidenced above, it should be noted that sophisticated blade industry suddenly appeared in assemblages from 8400 to 8000 cal BP, which well corresponds with the duration of 8.2 kyr event, while detailed environmental change influenced by 8.2 ka event in Hokkaido is not evident now and left for the future work.

Considering that sophisticated blade technology already appeared, hundreds or a thousand years prior to Hokkaido, in Sakhalin Island which is located to the north of Hokkaido, above mentioned chronological match between the appearance of blade technology in Hokkaido and 8.2 ka event implies the event influenced the diffusion of blade technology from Sakhalin Island (Kunikita 2014; Morisaki 2011, 2014). If this supposition is true, the diachronic technological gap in Hokkaido could also be explained reasonably (Morisaki 2015). Although this relationship should still be more discussed in near future, referencing the latest data in Sakhalin Island (Grishchenko, 2011), sudden appearance of sophisticated blade technology might have been caused not only by population dynamics or ‘cultural diffusion’, but by rapid change in environmental condition.

It might not be easy to recognize correspondence between Holocene environmental change and lithic technological change as clearly as this, but similar situation was already pointed out in the Lower Amur region in Russian Far East, too (Morisaki and Sato 2015). Further investigation on human response to Holocene climatic anomaly widely through East Asia, adopting various other method like paleo-dietary analysis, archaeological settlement-subsistence analysis, use-wear analysis, obsidian provenience analysis, as well as radiocarbon dating, will provide new perspective on adaptive history of Holocene hunter-gatherer society.

## 5. Conclusions

This paper presented newly conducted radiocarbon dating on charred residue on potteries from Initial Jomon sites of northeastern Hokkaido. This work evidenced current pottery typological chronology and allows us to check diachronic lithic technological change associated with these potteries, then to correlate it with worldwide climatic fluctuation which occurred in terminal Early Holocene.

As the result, it is likely that 8.2 ka climatic event was responsible for sudden appearance of sophisticated blade technology in Hokkaido. At present, regional environmental change driven by this global climatic fluctuation is not detailed yet, but there is enough possibility that sudden appearance of sophisticated blade technology might have been caused not only by simple population dynamics or diffusion, but by rapid change in environmental condition. Future progress of regional paleo-environmental study of this period will contribute to elucidation of this problem, and ultimate goal of this study is to clarify how hunter-gatherer societies in each region interacted with each other and adapted to environmental change.

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## References

Alley, R.B., Ágústsdóttir, A.M., 2005. The 8 k event: cause and consequences of a major Holocene abrupt climate change. Quat. Sci. Rev. 24, 1123–1149.

Alley, R.B., Mayewski, P.A., Sowers, T., Stuiver, M., Taylor, K.C., Clark, P.U., 1997. Holocene climatic instability: a prominent, widespread event 8200 yr ago. Geology 25-6, 483–486.

Butzer, K.W., 1982. Archaeology as human ecology: method and theory for a contextual approach. Cambridge University Press, New York.

Cheng, H., Fleitmann, D., Lawrence Edwards, R., Wang, X., Cruz, F.W., Auler, A.S., Mangini, A., Wang, Y., Kong, X., Burns, S.J., Matter, A., 2009. Timing and structure of the 8.2 kyr B.P. event inferred from $\delta^{18}$O records of stalagmites from China, Oman, and Brazil. Geology 37-11, 1007–1010.

Goto, H., Yamahara, T., 2008. On potteries with flat base and streaked surface (northeastern Hokkaido). In: Kobayashi, T. (Ed.), The Handbook of Jomon Pottery. UM promotion, Tokyo, pp. 60–65 (In Japanese).

Grishchenko, V., 2011. Rannii Neolit Ostrova Sakhalin. Sakhalin State University, Yuzhno-Sakhalinsk (In Russian).

Investigation team of the Yubetsu-Ichikawa site, 2015. Archaeological Study on the Neolithization/Jomonization Process in the Northern Boundary Region of the Japanese Archipelago: Research of the Yubetsu-Ichikawa Site. Tokoro Research Laboratory, Graduate School of Humanities and Sociology, University of Tokyo, Tokyo (In Japanese with English abstract).

Iwasaki, T., Hata, H., Sawa, S., Nishi, Y., 1980. Excavation at Higashikushiro site location II. Kushiro shiritsu kyodo hakubutsukanpo 7, 57–70 (In Japanese).

Kitazawa, M., 2008. On Tenneru-Akatsuki type pottery and potteries with shell made decoration. In: Kobayashi, T. (Ed.), The Handbook of Jomon Pottery. UM promotion, Tokyo, pp. 54–59 (In Japanese).

Kobashi, T., Severinghausa, J.P., Brookb,E.J., Barnolac, J., Grachev, A.M., 2007. Precise timing and characterization of abrupt climate change 8200 years ago from air trapped in polar ice. Quat. Sci. Rev. 26, 1212–1222.

Kunikita, D., 2014. Radiocarbon dates of blade arrowhead industry. In: Fukuda, M. (Ed.), Toward a New Understanding of the Beginning of the Holocene Aroud the Northern Circum Japan Sea. The University of Tokyo, Tokyo, pp. 25–34 (In Japanese).

Kunikita, D., Yoshida, K., Miyazaki, Y., Saito, K., Endo, A., Matsuzaki, H., Ito, S., Kobayashi, T., Fujimoto, T., Kuznetsov, A.M., Krupyanko, A.A., Tabarev, A.M., 2007. Analysis of radiocarbon dates of an archaeological site in the Russian Far East: the marine reservoir effect as seen on charred remains on pottery. Nucl. Inst. Methods Phys. Res. B 259, 467–473.

Kunikita, D., Shevkomud, I., Yoshida, K., Onuki, S., Yamahara, T., Masuzaki, H., 2013. Dating charred remains on pottery and analyzing food habits in the Early Neolithic period in Northeast Asia. Radiocarbon 55, 1334–1340.

Kushiro Kokogaku Kenkyukai, 1987. Excavation Report of Sakuragaoka 2 Site. Kushiro Kokogaku Kenkyukai, Kushiro (In Japanese).

Kushiro Kokogaku Kenkyukai, 1988. Excavation Report of Sakuragaoka 1 and 2 Site. Kushiro Kokogaku, Kushiro (In Japanese).
Kushiro Kokogaku Kenkyukai, 1990. Excavation Report of Zaimokucho 5 Site. Kushiro Kokogaku Kenkyukai, Kushiro (In Japanese).
Kuzmin, Y.V., Burr, G.S., Jull, A.J.T., 2001. Radiocarbon reservoir correction ages in the Peter the Great Gulf, Sea of Japan, and eastern coast of the Kunashir, southern Kuriles (Northwestern Pacific). Radioarbon 43, 477–481.
Memanbetsu Town Board of Education, 1992. Excavation Report of Memanbetsucho Toyosato Sekijin Site, Sumiyoshi C Site. Memanbetsu Town Board of Education, Memanbetsu (In Japanese).
Morisaki, K., 2011. Lithic chronology of the Russian Far East and the appearance of blade arrowhead. In: Kumaki, T. (Ed.), Fukuda, M., Shevkomud, I·Ya. The University of Tokyo, Tokyo, A study on the formation and transformation process of sedentary food gathering society in Northeast Asia, pp. 178–200 (In Japanese).
Morisaki, K., 2014. On lithic assemblages including blade arrowheads in the Russian Far East. In: Fukuda, M. (Ed.), Toward a New Understanding of the Beginning of the Holocene Aroud the Northern Circum Japan Sea. The University of Tokyo, Tokyo, pp. 17–24 (In Japanese).
Morisaki, K., 2015. Early and Middle Neolithic lithic industry and regional variation in Russian Far East. Proceedings of Research Association of North Asia. Vol. 16, pp. 27–30 (In Japanese).
Morisaki, K., Sato, H., 2015. Hunter gatherer responses to abrupt environmental change from the terminal Pleistocene to the Early Holocene in the Lowe Amur region. In: Sazelova, S., Novak, M., Mizerova, A. (Eds.), Forgotten Times and Spaces: New Perspectives in Paleoanthropological, Paleoetnological and Archeological Studies. Institute of Archeology of the Czech Academy of Sciences, Masaryk University, Brno, pp. 418–434.
Nomura, Udagawa (Eds.), 2001. Hokkaido no Kodai 1: Kyusekki-Jomon Bunka. Hokkaido Shinbunsha, Sapporo (In Japanese).
Nishi, Y., 1997. Pottery Groups of Early Initial Jomon in Eastern Hokkaido. in: Kurata, Yoshiro sensei kokikinen kai (Ed.), Seisan no Kokogaku. Doseisha, Tokyo, pp. 21-33 (In Japanese).
Obihiro City Board of Education, 2005. Obihiro Taisho iseki 1. Obihiro City Board of Education, Obihiro (In Japanese).
Obihiro City Board of Education, 2006. Obihiro Taisho iseki 2. Obihiro City Board of Education, Obihiro (In Japanese).
Obihiro City Board of Education, 2008. Obihiro Taisho iseki 3. Obihiro City Board of Education, Obihiro (In Japanese).
Okamura, M., 1997. The formation of Jomon culture in the southern and northern parts of Japanese Islands. Daiyonki kenkyu 36-5, 319–328 (In Japanese with English abstract).
Obihiro City Board of Education, 1990. Yachiyo a Iseki. Obihiro City Board of Education, Obihiro (In Japanese).
Sato, K., 1980. Tarumae tephra Ta-d and initial Jomon. Hokkaidokokogaku 16, 15–32 (In Japanese).
Sawa, S., 1968. Chronological position of blade arrowhead industry in Kushiro region. Shin Kushiroshishi kaiho 2-3, 12–17 (In Japanese).
Sawa, S., Nishi, Y., Yamazaki, S., Yamamoto, F., Matsuda, T., 1971a. Excavation at Higashikushiro site location 1, S45. Kushiro shiritsu hakubutsukanpo 209, 87–94 (In Japanese).
Sawa, S., Nishi, Y., Yamazaki, S., Yamamoto, F., Matsuda, T., 1971b. Excavation at Higashikushiro site location 1, S46. Kushiro shiritsu hakubutsukanpo 212, 4–10 (In Japanese).
Selvaraj, K., Chen, C.-T.A., Lou, J.-Y., 2008. Holocene weak summer East Asian monsoon intervals in subtropical Taiwan and their global synchronicity. Clim. Past Discuss. 4, 929–953.
Takakura, J., 1999. Restoration of Mobility and Settlement System in Initial Holocene. Hokkaido University, Sapporo (In Japanese).
Tominaga, K., 2008. Initial Jomon period in Hokkaido. In: Sato, H. (Ed.), The Process of Jomonization. Rokuichi-shobo, Tokyo, pp. 53–76 (In Japanese).
Toyohara, T., 2000a. Archaeological sites along Kushiro River Basin, no.1. Kushiro shiritsu hakubutsukan kanpo 369, 3–6 (In Japanese).
Toyohara, T., 2000b. Archaeological sites along Kushiro River Basin, no.2. Kushiro shiritsu hakubutsukan kanpo 371, 3–6 (In Japanese).
Urahoro Town Board of Education, 1976. Kyoei B Iseki. Urahoro Town Board of Education, Urahoro (In Japanese).
University of Tokyo, Faculty of Letters, 1963. Ohotsukukai engan. University of Tokyo, Faculty of Letters, Tokyo, Shiretokohanto no iseki (In Japanese).
Wang, Y., Cheng, H., Lawrence, E.R., He, Y., Kong, X., An, Z., Wu, J., Kellym, M.J., Dykoski, C.A., Li, X., 2005. The Holocene Asian monsoon: links to solar changes and North Atlantic climates. Science 308, 854–857.
Yubetsu-Ichikawa research team, 2015. Nihonretto Hokuheniki ni okeru shinsekki/Jomonka no purosesu ni kansuru kokogakuteki kenkyu. The University of Tokyo, Graduate School of Frontier Sciences and Graduate School of Humanities and Sociology, Kashiwa (In Japanese with English abstract).
Yamada, 2011. Economics of site formation in lithic source area: a study by field processing model. Palaeolith. Res. 7, 75–91.
Yamahara, T., 2008. Humans from terminal pleistocene to initial holocene in Hokkaido. In: Sato, H. (Ed.), The Process of Jomonization. Rokuichi-shobo, Tokyo, pp. 35–52 (In Japanese).
Yoneda, M., Uno, H., Shibata, Y., Suzuki, R., Kumamoto, Y., Yoshida, K., Sasaki, T., Suzuki, A., Kawahata, H., 2007. Radiocarbon marine reservoir ages in the western Pacific estimated by pre-bomb molluscan shells. Nucl. Inst. Methods Phys. Res. B 259, 432–437.
Yonemura, T., 1997. Chuo a Site. Memanbetsu Town Board of Education, Memanbetsu (In Japanese).
Yoshida, K., Ohmichi, J., Kinose, M., Iijima, H., Oono, A., Abe, N., Miyazaki, Y., Matsuzaki, H., 2004. The application of $^{14}C$ dating to potsherds of the Jomon period. Nucl. Inst. Methods Phys. Res. B 223-224, 716–722.